AD-A278 044

ARI Research Note 94-09

Predicting Table VIII Tank Gunnery Scores From a Test of GUARDFIST I Proficiency and Training Matrix Advancement

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November 1993

94-11134

United States Army
Research Institute for the Behavioral and Social Sciences

94 4 12 070

U.S. ARMY RESEARCH INSTITUTE FOR THE BEHAVIORAL AND SOCIAL SCIENCES

A Field Operating Agency Under the Jurisdiction of the Deputy Chief of Staff for Personnel

EDGAR M. JOHNSON
Director

Research accomplished under contract for the Department of the Army

CAE-Link Corporation

Technical review by

Ronald E. Kraemer

Accesion For	
NTIS CRA&I	☑
DTIC TAB	☐
Unannounced	☐
Justification	
By	
Distribution /	
Availability Codes	
Dist	Avail and / or Special
A-1	

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REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	1993, November	Final Oct 92 - Apr 93

4. TITLE AND SUBTITLE
Predicting Table VIII Tank Gunnery Scores From a Test of GUARDFIST I Proficiency and Training Matrix Advancement

5. FUNDING NUMBERS
DABT60-87-C-02776
63007A
795
2125
C01

6. AUTHOR(S)
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8. PERFORMING ORGANIZATION REPORT NUMBER
--

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U.S. Army Research Institute for the Behavioral and Social Sciences
ATTN: PERI-IKD
5001 Eisenhower Avenue
Alexandria, VA 22333-5600

10. SPONSORING/MONITORING AGENCY REPORT NUMBER
ARI Research Note 94-09

11. SUPPLEMENTARY NOTES
Funding provided by National Guard Bureau (NGB-ARO), 111 S. George Mason Drive, Arlington, VA 22204

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release;
distribution is unlimited.

12b. DISTRIBUTION CODE
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13. ABSTRACT *(Maximum 200 words)*

This report describes two investigations of the relationship between performance on the Guard Unit Armory Device Full-Crew Interactive Simulation Trainer--Armor (GUARDFIST I) and live-fire tank gunnery performance. In the first investigation, 19 Army National Guard (ARNG) M1 tank crews completed a GUARDFIST I-based test of gunnery proficiency and then fired tank gunnery Table VIII during annual training. Results showed that crew performance on the GUARDFIST I test was unrelated to performance on Table VIII. The second investigation examined the relationship between aggregate measures of GUARDFIST I training (maximum training matrix advancement and total training time) and Table VIII scores collected 6 months later on eight ARNG M1 tank crews. Results showed that total training time was unrelated to Table VIII scores, but that maximum training matrix advancement was strongly predictive of subsequent Table VIII performance. Findings suggest that brief, one-shot tests of proficiency on GUARDFIST I have limited predictive utility, but that aggregate measures of gunnery proficiency on GUARDFIST I can be used to predict

(Continued)

14. SUBJECT TERMS

Reserve Component	Tank gunnery
Training devices	GUARDFIST I
Armor training	Performance prediction

15. NUMBER OF PAGES
16

16. PRICE CODE
--

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	Unlimited

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std Z39-18
298-102

13. ABSTRACT (Continued)

live-fire tank gunnery performance. A larger sample size is needed to substantiate the validity of this predictive relationship.

PREDICTING TABLE VIII TANK GUNNERY SCORES FROM A TEST OF GUARDFIST I PROFICIENCY AND TRAINING MATRIX ADVANCEMENT

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Background

To enhance Reserve Component (RC) home-station training, especially for combat arms units, the National Guard Bureau is seeking to use technology in the form of simulators and training devices (Morrison, Drucker & Campshure, 1991). To guide the use of this technology and thereby promote the successful RC transition from equipment-based to device-based training in the area of tank gunnery, Morrison, Campshure and Doyle (1991) developed a strategy that links device-based training with tank-based training and evaluation. Under this strategy, the purpose of device-based training is to prepare individuals, crews, and platoons to be trained on the tank combat tables, with these tables providing the intermediate and terminal performance objectives for gunnery training.

Many recommendations of the present device-based training strategy are based on best available information. In some cases, however, this information is incomplete, resulting in recommendations predicated on speculation and nonvalidated concepts. In an attempt to close these information gaps, follow-up research is being conducted to provide a better empirical basis for recommendations in areas where uncertainty exists. Two areas of the strategy that have received recent attention are the validity of device-based training and associated diagnostic tests.

The Morrison, Campshure, and Doyle (1991) strategy (p. 36, Figure 6) recommends a sequence of training events that includes device-based training and diagnostic tests. In the recommended sequence, device-based training occurs first, followed by diagnostic tests. These diagnostic tests serve as performance gates that must be passed prior to on-tank training and evaluation. For example, following device-based training, crews must demonstrate proficiency on basic device-based diagnostics before proceeding to Gunnery Tables I-IV. Similarly, proficiency on device-based intermediate diagnostics is required before proceeding to Gunnery Tables V-VIII.

The device-based diagnostic test exercises were selected to give the closest possible match to the engagement conditions (e.g., tank and target movement) experienced during the conduct of on-tank tables for each training phase. The purpose of matching diagnostic tests to particular tank table conditions was to increase the potential of predicting live-fire table performance from device-based test performance. Although the speculation that performance on such diagnostic tests should

correlate positively with on-tank performance is a reasonable hypothesis, a body of empirical evidence must be accumulated before the predictive validity of these device-based tests can be accepted.

Research has focused on two training devices: (a) the Mobile Conduct-of-Fire Trainer (M-COFT) [Department of the Army, 1988a; General Electric, 1989], and (b) the Guard Unit Armory Device Full-Crew Interactive Simulation Trainer - Armor (GUARDFIST I) [Department of the Army, 1990]. Smith and Hagman (1992) reported significant correlations between M-COFT hit rate scores (Hoffman & Witmer, 1989) and live-fire performance on Tank Table VIII. No investigations have been reported, however, of relationships between GUARDFIST I hit rate scores and GUARDFIST I prior training and live-fire performance on Tank Table VIII.

Purpose of the Research

The present research documents the development of a GUARDFIST I gunnery proficiency test, investigates the relationship between this test and Table VIII scores, and examines the relationship between prior training on GUARDFIST I and Table VIII performance.

Experiment 1

Method

Participants. Nineteen crews from the 2nd Battalion, 116th Cavalry Brigade of the Idaho Army National Guard served as participants.

Procedure. Crews took the GUARDFIST I gunnery proficiency test and then fired Table VIII the next day as part of Annual Training (AT), 1992. Table data included a day score (based on six engagements), a night score (based on four engagements), and a total score (based on all 10 engagements). Total scores could range from 0 to 1,000, and a score of 700 was required for crew qualification (Department of the Army, 1988b). GUARDFIST I test data were obtained from a variety of engagement conditions. As shown in Figure 1, 17 tasks were included from five group/exercise combinations taken from the current GUARDFIST I training matrix (Department of the Army, 1990). Across tasks, testing conditions were varied to include day and night engagements requiring use of the gunner's primary sight (GPS), gunner's auxiliary sight (GAS), thermal imaging sight (TIS), both full-crew and 3-man (gunner missing) conditions, nuclear, biological, and chemical (NBC) conditions and both a stationary and moving tank firing at a total of 30 stationary and moving targets ranging from 800-2000m.

ENGAGEMENT CONDITIONS

Group/Ex	Task	Sight	Tank	Target	Range(m)	3-man	NBC
2/1	1	GPS	S	S (tank)	900-1500	Yes	No
		GPS	S	S (tank)	900-1500	Yes	No
	2	GPS	S	S (tank)	900-1700	Yes	No
		GPS	S	S (tank)	900-1700	Yes	No
4/4	1	TIS	S	S (tank)	1400-1600	No	No
	2	TIS	S	S (tank)	1400-1600	No	No
		TIS	S	M (tank)	1400-1600	No	No
	3	TIS	S	S (tank)	900-1200	No	No
		TIS	S	S (tank)	900-1200	No	No
4/6	1	TIS	M	M (tank)	1400-1600	No	No
		TIS	M	S (tank)	1400-1600	No	No
	2	TIS	M	M (BRDM)	1700-1900	No	No
		TIS	M	M (ZSU)	1700-1900	No	No
	3	TIS	M	S (troops)	800-1000	No	No
		TIS	M	S (troops)	800-1000	No	No
	4	TIS	M	M (BMP)	1400-1600	No	No
		TIS	M	M (BMP)	1400-1600	No	No
3/3	1	GAS	S	S (BMP)	500- 700	No	No
		GAS	S	S (BRDM)	500- 700	No	No
	2	GAS	S	M (tank)	900-1100	No	No
		GAS	S	S (tank)	900-1100	No	No
	3	GAS	S	S (tank)	900-1100	No	No
		GAS	S	S (tank)	900-1100	No	No
	4	GAS	S	S (BMP)	1400-1500	No	No
		GAS	S	S (ZSU)	1400-1500	No	No
5/3	1	GPS	M	S (tank)	1900-2000	No	Yes
	2	GPS	M	S (tank)	1800-2000	No	Yes
	3	GPS	M	M (BMP)	1600-1800	No	Yes
	4	GPS	M	M (tank)	1400-1600	No	Yes
		GPS	M	M (tank)	1400-1600	No	Yes

Figure 1. GUARDFIST I test engagement conditions.
(S = Stationary, M = Moving)

The GUARDFIST I test took approximately 1 hr and 15 min to complete and was administered to all crews by the same Instructor/Operator (I/O). All crews had previously received familiarization training with GUARDFIST I, and eight crews had spent approximately 3 additional hr training with the device during the training year prior to AT. The GUARDFIST I test was scored according to criteria developed by Hoffman and Witmer (1989) to produce Fire Rate, Hit Proportion, and Hit Rate scores. Composite scores were calculated using data from all five exercises. Additionally, offensive Fire Rate, Hit Proportion and Hit Rate scores were calculated from exercises containing exclusively offensive engagements (Exercises 4/6 and 5/3 in

Figure 1) and defensive scores were calculated from exercises containing exclusively defensive engagements (Exercises 2/1, 4/4, and 3/3 in Figure 1).

Hit Rate, the most comprehensive of the three measures produced by the Hoffman and Witmer (1989) scoring procedure, is an aggregate measure of gunnery proficiency weighted for the number of targets in each engagement. Hoffman and Witmer (1989) define Hit Rate as:

$$\underset{\text{(hits/time)}}{\text{Hit Rate}} = \underset{\text{(hits/rounds)}}{\text{Hit Proportion}} \times \underset{\text{(rounds/time)}}{\text{Fire Rate}}$$

Thus, "Hit rate ... is the recommended metric for assessment of overall crew proficiency .... Hit rate is calculated from the weighted averages for firing rate and hit probability, where engagement firing rates and hit probabilities are weighted by the number of targets in the engagement" (see Hoffman and Witmer, 1989 for details). Although the scoring procedure for Hit Rate is computationally complex and laborious, it includes in a single metric the essential elements of gunnery success: rounds fired, time expended, accuracy of fire, and completeness (were all threat targets hit?), and can be captured from performance printouts provided by GUARDFIST I.

Results

Table VIII total scores ranged from 383 to 921, with a mean of 632 and a SD of 139.43. Six of the 19 crews (31.6%) obtained Table VIII total scores in excess of the 700 cut-score required for Table VIII qualification. GUARDFIST I composite hit rate ranged from .020 to .045, with a mean of .033 and SD = .007.

Table 1 summarizes the correlations between Table VIII scores (day, night and total) and the three key measures from the GUARDFIST I gunnery test (Fire Rate, Hit Proportion and Hit Rate). None of the coefficients of correlation in Table 1 are statistically significant, $p < .05$.

The lack of significant relationships raises the question: was no relationship detected because none exists between performance on the GUARDFIST I test and Table VIII scores, or because of flawed measurement? Both Smith and Hagman (1992) and Campshure and Drucker (1990) commented that the COFT device correlated significantly with Table VIII scores only when device performance was indexed by the broadest possible measure. Smith and Hagman (1992) incorporated composite performance measures along with other variables within an analytic procedure that permitted simultaneous examination of multiple predictors. Campshure and Drucker (1990) used COFT matrix position as a predictor, based on aggregated training sessions. In this context, matrix position was a measure of maximum advancement into a training matrix over multiple training sessions.

Table 1

Correlations Between Table VIII Total Score, Day Score, and Night Score and GUARDFIST I Fire Rate, Hit Proportion, and Hit Rate.

	Table VIII Score		
GUARDFIST I	Total	Day	Night
All Exercises			
Fire Rate	-.21	-.07	-.28
Hit Proportion	-.24	-.41	.17
Hit Rate	-.26	-.36	.05
Offensive Exercises			
Fire Rate	-.28	-.27	-.10
Hit Proportion	-.12	-.12	-.03
Hit Rate	-.17	-.24	.07
Defensive Exercises			
Fire Rate	.03	.12	-.14
Hit Proportion	-.06	-.06	.22
Hit Rate	-.10	-.15	.05

Note. n = 18 for Offensive Exercises. n = 19 for all other tests.

Discussion

Both empirical and logical grounds suggest that composite measures are more stable than specific test performance scores. Table VIII performance represents a multi-faceted composite of many behaviors (including cognitive, motivational, and perceptual-motor functioning) as well as quality, extent and intensity of prior training. Because of the complexity of the criterion measure, only a composite sampling of device performance, encompassing a broad array of specific combat-relevant behaviors, can reasonably be expected to predict Table VIII outcomes.

Is it possible that the GUARDFIST I gunnery test used in the present investigation, although consisting of five exercises and lasting 75 min, was too specific? Would a more aggregated measure of GUARDFIST I performance have better predicted subsequent Table VIII scores? These questions cannot be answered within the context of the present investigation. However, 8 of the 19 crews shooting Table VIII as part of the present investigation had spent approximately 3 additional hr training with the GUARDFIST I device during the training year prior to AT, and one of the training measures collected during that training was matrix advancement (maximum advancement into the GUARDFIST I training matrix, a measure similar to that used by Campshure and

Drucker (1990) in their investigation of the COFT-to-live-fire relationship.

Experiment 2

Method

GUARDFIST I training was accomplished with a training matrix modified to include specific tasks pertaining to anticipated Table VIII engagement conditions (see Smith & Hagman, 1993, for details). The GUARDFIST I training matrix was divided into tasks, which are individual engagements comprising multiple targets (usually two).

Each crew was scheduled for one training session at their local armory during three consecutive inactive duty training weekends (October, November, December). Amount of training time that each crew received during each session varied. Total training time for the eight crews averaged 168 min and ranged from 85 to 220 min. Prior to training, crews were informed that both speed and accuracy were important. Feedback was provided by the I/O during training to promote learning. Crews were encouraged to advance as far as possible into the training matrix, but could proceed to the next training unit only when they received a "GO" from the training device. A "NO GO" resulted in a repeat of the same task. Crews could repeat a task as often as necessary to achieve a "GO." Maximum matrix advancement averaged 64.5 training tasks, with a standard deviation of 18.3 and range of 40 to 89.

Two training performance measures were collected: (a) maximum matrix advancement, and (b) training time (total combined training time in min across all training sessions). Table VIII scores were collected 6 months later during AT.

Results

Maximum matrix advancement, an aggregate measure of GUARDFIST I training, correlated significantly with subsequent Table VIII total score. As indicated in Table 2, the significant relationship was traceable principally to the day score component. Tank Table VIII night scores were negligibly correlated with matrix advancement. Training time, moreover, was not significantly related to any component of Table VIII scores.

Using the matrix advancement variable, a regression equation, $F(1,6) = 17.16$, $p < .01$, indicated that:

Predicted Table VIII = matrix advancement (5.73) + 198.73

The relationship between matrix advancement and Table VIII scores is graphically depicted in Figure 2.

Table 2

Correlations Between GUARDFIST I Maximum Matrix Advancement and Day and Night Components of Table VIII Scores (n = 8)

	Matrix Advancement	Training Time
Total Score	.86*	.32
Day Score	.67	.30
Night Score	.33	.04

* $p < .01$

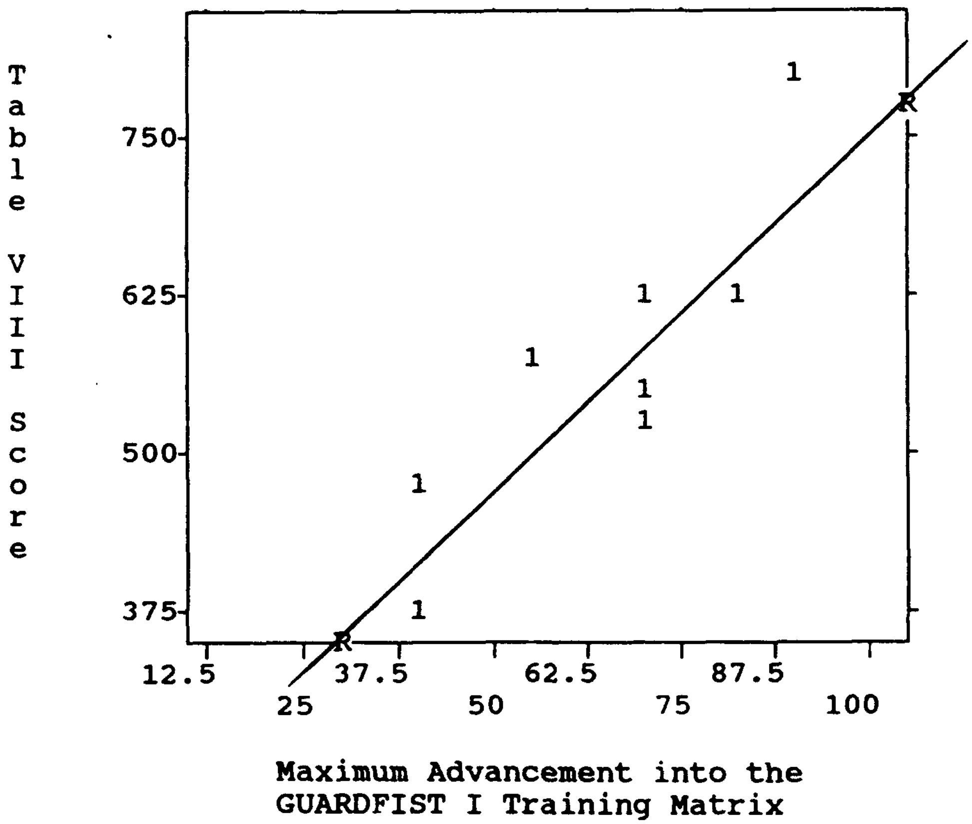

Figure 2. Plot of Table VIII total score with maximum advancement into the GUARDFIST I training matrix ($n = 8$, $r = .86$, $p < .01$). Table VIII score = 5.73 (maximum matrix advancement) + 198.73.

Discussion

Consistent with earlier research on the COFT device by Smith and Hagman (1992) and Campshure and Drucker (1990), the present investigation of the GUARDFIST I device suggests that brief (one-shot) training device test scores have limited utility in predicting subsequent live-fire tank gunnery performance. However, aggregate scores (presumably more adequately representing device competency) reliably predict subsequent Table VIII scores, even when the time interval separating the two measures is 6 months. A significant relationship between aggregated device scores and Table VIII performance was found with GUARDFIST I in this investigation, and with COFT in earlier research (Campshure & Drucker, 1990; Smith & Hagman, 1992).

Amount of GUARDFIST I training time was not related to subsequent Table VIII performance. This finding, coupled with the fact that matrix advancement was related to subsequent Table VIII scores, suggests that it was not the amount of time expended in training, per se, but the quality of that training time that was important. The same crews that efficiently advanced farther into the training matrix were the same crews that, six months later during AT, obtained higher Table VIII scores.

The evidence, though piecemeal, is beginning to suggest that both GUARDFIST I and COFT manifest predictive usefulness. However, it appears that a broad-based measure of device competency is critical to demonstrating the live-fire-to device relationship. As discussed by Smith and Hagman (1992), a COFT-based test should be at least 1 hr in length. Moreover, the present investigation suggests that even more aggregated measures of GUARDFIST I device competency may be necessary.

A compelling finding in this investigation was the significant relationship between GUARDFIST I training matrix advancement and subsequent Table VIII scores. On the surface, this seems to suggest that more training (greater advancement into the training matrix) will produce better Table VIII performance. However, training time, per se, did not predict Table VIII scores. Thus, causal interpretations of the obtained finding must be advanced cautiously. For example, it is not possible to conclude that GUARDFIST I training produced better subsequent Table VIII scores. (Although this may have been the case, the interpretation goes beyond the design and data constraints of the present investigation.) A plausible alternative explanation for the finding is that highly motivated crews conscientiously applied themselves to device-based training opportunities and subsequently did well on Table VIII, while less motivated crews failed to optimize device-based training opportunities and subsequently did poorly on Table VIII. Nonetheless, even if this alternative explanation is accepted, it still suggests that a program of carefully monitored device-based training can be used to separate crews into those likely to do

either poorly or well on subsequent Table VIII qualification trials. Although suggestive, a larger sample size is needed to determine the validity of this conclusion.

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